



U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

3.5.1.6 AIRCRAFT HAZARDS

REVIEW RESPONSIBILITIES

Primary - Siting Analysis Branch (SAB)

Secondary - None

I. AREAS OF REVIEW

The staff reviews the applicant's assessment of aircraft hazards. The purpose of the review is to assure that the risks due to aircraft hazards are sufficiently low. Probabilistic considerations may be used to demonstrate that aircraft hazards need not be a design basis concern. Otherwise, design basis aircraft identification is made and the applicant's plant design is evaluated to assure that it is protected against the potential effects of aircraft impacts and fires.

The SAB reviews the applicant's assessment of aircraft hazards to the plant and determines whether or not they should be incorporated into the plant design basis. If the aircraft hazards are incorporated into the plant design basis, the SAB identifies and describes the design basis aircraft in terms of aircraft weight, speed, and other appropriate characteristics.

On request by SAB, the following branches with primary review responsibility will review specific aspects of aircraft hazards:

1. The Structural Engineering Branch (SEB), in the area of missile effects (SRP Section 3.5.3), with respect to aircraft impacts,
2. The Chemical Engineering Branch (CMEB), in the area of fire protection (SRP Section 9.5.1), with respect to aircraft fires, and
3. The Auxiliary Systems Branch (ASB), in the area of structures, systems, and components (SSC) important to safety (SRP Section 3.5.2), with respect to protection requirements against aircraft crashes.

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USNRC STANDARD REVIEW PLAN

Standard review plans are prepared for the guidance of the Office of Nuclear Reactor Regulation staff responsible for the review of applications to construct and operate nuclear power plants. These documents are made available to the public as part of the Commission's policy to inform the nuclear industry and the general public of regulatory procedures and policies. Standard review plans are not substitutes for regulatory guides or the Commission's regulations and compliance with them is not required. The standard review plan sections are keyed to the Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants. Not all sections of the Standard Format have a corresponding review plan.

Published standard review plans will be revised periodically, as appropriate, to accommodate comments and to reflect new information and experience.

Comments and suggestions for improvement will be considered and should be sent to the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Washington, D.C. 20555.

4. For those areas of review identified above as being part of the primary responsibility of other branches, the acceptance criteria necessary for the review and the methods of their application are contained in the referenced SRP sections of the corresponding primary branches.
5. The Applied Statistics Branch (ASB/MPA) will provide technical review support with respect to aircraft accident statistics.

II. ACCEPTANCE CRITERIA

SAB acceptance criteria are based on meeting the relevant requirements of one of the following sets of regulations:

1. 10 CFR Part 100, §100.10 as it relates to indicating that the site location, in conjunction with other considerations (such as plant design, construction, and operation), should insure a low risk of public exposure. This requirement is met if the probability of aircraft accidents resulting in radiological consequences greater than 10 CFR Part 100 exposure guidelines is less than about 10^{-7} per year (see SRP Section 2.2.3). The probability is considered to be less than about 10^{-7} per year by inspection if the distances from the plant meet all the requirements listed below:
 - (a) The plant-to-airport distance D is between 5 and 10 statute miles, and the projected annual number of operations is less than $500 D^2$, or the plant-to-airport distance D is greater than 10 statute miles, and the projected annual number of operations is less than $1000 D^2$,
 - (b) The plant is at least 5 statute miles from the edge of military training routes, including low-level training routes, except for those associated with a usage greater than 1000 flights per year, or where activities (such as practice bombing) may create an unusual stress situation,
 - (c) The plant is at least 2 statute miles beyond the nearest edge of a federal airway, holding pattern, or approach pattern.

If the above proximity criteria are not met, or if sufficiently hazardous military activities are identified (see item b above), a detailed review of aircraft hazards must be performed. Aircraft accidents which could lead to radiological consequences in excess of the exposure guidelines of 10 CFR Part 100 with a probability of occurrence greater than about 10^{-7} per year should be considered in the design of the plant. If the results of the review do not support a finding that the risk due to aircraft activities is acceptably low, then the design basis acceptance criteria outlined in Item II.2 below applies.

2. General Design Criterion (GDC) 4 of 10 CFR Part 50 (Ref. 13), Appendix A, requires that structures, systems, and components (SSC) important to safety be appropriately protected against the effects of missiles that may result from events and conditions outside the nuclear power unit. GDC 3 of 10 CFR Part 50, Appendix A, requires that SSC important to safety be appropriately protected against the effects of fires. The plant meets the relevant requirements of GDC 3 and GDC 4, and is considered appropriately protected against design basis aircraft impacts (Ref. 6) and fires (Ref. 3) if the SSC important to safety are capable of withstanding the effects of the

postulated aircraft impacts and fires without loss of safe shutdown capability, and without causing a release of radioactivity which would exceed 10 CFR Part 100 dose guidelines.

The safety-related SSC to be considered with respect to the above acceptance criteria include those described in the Appendix to Regulatory Guide 1.117, "Structures, Systems, and Components of Light-Water-Cooled Reactors to be Protected Against Tornadoes." Other safety-related SSC, which may not be included in Regulatory Guide 1.117, will be considered on a case-by-case basis in accordance with the acceptance criteria of the appropriate branches having primary responsibility for their protection.

III. REVIEW PROCEDURES

The reviewer selects and emphasizes aspects of the areas covered by this SRP section as may be appropriate for a particular case. The judgment on areas to be given attention and emphasis in the review is based on a inspection of the material presented to see whether it is similar to that recently reviewed on other plants and whether items of special safety significant are involved.

The staff's review of the aircraft hazard assessment consists of the following steps:

1. **Aviation Uses.** Data describing aviation uses in the airspace near the proposed site, including airports and their approach paths, federal airways, Federal Aviation Administration (FAA) restricted areas, and military uses is obtained from Section 2.2.1-2.2.2 of the SAR. For many cases, no detailed analysis need be made as the probability can be judged adequately low based on a comparison with analyses previously performed (Refs. 5, 7, 8, 9 and 10). In general, civilian and military maps should be examined to verify that all aviation facilities of interest have been considered. In the process, the reviewer should develop an independent assessment of the aircraft hazards. Communications with agencies responsible for aircraft operations and the evaluation of aircraft operational data may be utilized.
2. **Airways.** For situations where federal airways or aviation corridors pass through the vicinity of the site, the probability per year of an aircraft crashing into the plant (P_{FA}) should be estimated. This probability will depend on a number of factors such as the altitude and frequency of the flights, the width of the corridor, and the corresponding distribution of past accidents.

One way of calculating P_{FA} is by using the following expression:

$$P_{FA} = C \times N \times A/w$$

where:

C = inflight crash rate per mile for aircraft using airway,

w = width of airway (plus twice the distance from the airway edge to the site when the site is outside the airway) in miles,

N = number of flights per year along the airway, and

A = effective area of plant in square miles.

This gives a conservative upper bound on aircraft impact probability if care is taken in using values for the individual factors that are meaningful and conservative. For commercial aircraft a value of $C = 4 \times 10^{-10}$ (Ref. 11) per aircraft mile has been used. For heavily traveled corridors (greater than 100 flights per day), a more detailed analysis may be required to obtain a proper value for this factor.

3. Civilian and Military Airports and Heli-Ports (Refs. 2, 4, and 14). The probability of an aircraft crashing into the site should be estimated for cases where one or more of the conditions in Item II.1 of the Acceptance Criteria are not met.

The probability per year of an aircraft crashing into the site for these cases (P_A) may be calculated by using the following expression:

$$P_A = \sum_{i=1}^L \sum_{j=1}^M C_j N_{ij} A_j$$

where:

M = number of different types of aircraft using the airport,
L = number of flight trajectories affecting the site,
 C_j = probability per square mile of a crash per aircraft movement, for the jth aircraft,
 N_{ij} = number (per year) of movements by the jth aircraft along the ith flight path, and
 A_j = effective plant area (in square miles) for the jth aircraft.

The manner of interpreting the individual factors in the above equation may vary on a case-by-case basis because of the specific conditions of each case or because of changes in aircraft accident statistics.

Values for C_j currently being used are taken from the data summarized in the following table:

Distance From End of Runway (miles)	Probability ($\times 10^8$) of a Fatal Crash per Square Mile per Aircraft Movement			
	U.S. Air Carrier ¹	General Aviation ²	USN/USMC ¹	USAF ¹
0-1	16.7	84	8.3	5.7
1-2	4.0	15	1.1	2.3
2-3	0.96	6.2	0.33	1.1
3-4	0.68	3.8	0.31	0.42
4-5	0.27	1.2	0.20	0.40
5-6	0	NA ³	NA	NA
6-7	0	NA	NA	NA
7-8	0	NA	NA	NA
8-9	0.14	NA	NA	NA
9-10	0.12	NA	NA	NA

¹Reference 2.

²Reference 4.

³NA indicates that data was not available for this distance.

4. **Designated Airspaces.** For designated airspaces involving military or civilian usage, a detailed quantitative modeling of all operations should be verified. The results of the model should be the total probability (C) of an aircraft crash per unit area and time in the vicinity of the proposed site.

The probability per year of a potentially damaging crash at the site due to operations at the facility under consideration (P_M) is then given for this case by the following expression:

$$P_M = C \times A$$

where:

C = total probability of an aircraft crash per square mile per year in the vicinity of the site due to the airports being considered, and

A = effective area of one unit of the plant in square miles.

Where estimated risks due to military aircraft activity are found to be unacceptably high, suitable airspace or airway relocation should be implemented. Past experience has been that military authorities have been responsive to modification of military operations and relocation of training routes in close proximity to nuclear power plant sites. (Ref. 12)

5. **Holding Patterns.** Holding patterns are race track shaped courses at specified altitudes, associated with one or more radio-navigational facilities, where aircraft can "circle" while awaiting clearance to execute an approach to a landing at an airport or to continue along an airway. Holding patterns which are sufficiently distant from the plant need not be considered (See subsection II above). Otherwise, traffic in the holding pattern should be converted into equivalent aircraft passages taking into account the characteristics, including orientation with respect to the plant, of the holding pattern. The information in Item III.2 above should be used in this evaluation.
6. The total aircraft hazard probability at the site equals the sum of the individual probabilities obtained in the preceding steps.
7. The effective plant areas used in the calculations should include the following:
 - a. A shadow area of the plant elevation upon the horizontal plane based on the assumed crash angle for the different kinds of aircraft and failure modes.
 - b. A skid area around the plant as determined by the characteristics of the aircraft under consideration. Artificial berms or any other man-made and natural barriers should be taken into account in calculating this area.
 - c. The areas of those safety-related SSC which are susceptible to impact or fire damage as a result of aircraft crashes.

IV. EVALUATION FINDINGS

The reviewer drafts an introductory paragraph for the evaluation findings describing the procedure used in evaluating the aircraft hazards with respect to the safety-related SSC. The reviewer verifies that the site location is acceptable and meets the requirements of 10 CFR Part 100, §100.10.

The basis for the above findings may be strictly in terms of the probabilities associated with potential aircraft crashes onsite. If the aircraft crash statistics applicable to the onsite facilities are such that SRP Section 2.2.3 criteria are met without explicit consideration of plant design features, then conclusions of the following type should be included in the staff's safety evaluation report:

The staff concludes that the operation of the _____ plant in the vicinity of _____ does not present an undue risk to the health and safety of the public and meets the relevant requirements of 10 CFR Part 100, §100.10. This conclusion is based on the staff's independent verification of the applicant's assessment of aircraft hazards at the site that resulted in a probability less than about 10^{-7} per year for an accident having radiological consequences worse than the exposure guidelines of 10 CFR Part 100.

In addition, plant sites reviewed in the past which had equivalent aircraft traffic in equal or closer proximity were, after careful examination, found to present no undue risk to the safe operation of those plants. Based upon this experience, in the staff's judgment, no undue risk is present from aircraft hazard at the plant site now under consideration.

In the event that the staff evaluation of the aircraft hazards does not support the above basis, i.e., if SRP Section 2.2.3 criteria are not met, then the basis for acceptance is derived from applying GDC 3 and GDC 4 criteria. If the protection against aircraft impacts and fires is such that the plant safety-related SSC meet GDC 3 and GDC 4 criteria, then 10 CFR Part 100 requirements are considered to be met and conclusion of the following type may be included in the staff's safety evaluation report:

The staff concludes that the operation of the _____ plant in the vicinity of _____ does not present an undue risk to the health and safety of the public due to aircraft hazards and meets the relevant requirements of General Design Criteria 3 and 4. This conclusion is based on the staff having independently verified the applicant's assessment of aircraft hazards, including aircraft fires and impacts, at the site and that if the appropriate safety-related structures, systems, and components are designed to withstand the aircraft selected as the design basis aircraft, the probability of an aircraft strike causing radiological consequences in excess of the exposure guidelines of 10 CFR Part 100 is less than about 10^{-7} per year.

V. IMPLEMENTATION

The following is intended to provide guidance to applicants and licensees regarding the NRC staff's plans for using this SRP section.

Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, and method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced regulatory guides and NUREG.

VI. REFERENCES

1. 10 CFR Part 100, "Reactor Site Criteria."
2. D. G. Eisenhut, "Reactor Siting in the Vicinity of Airfields." Paper presented at the American Nuclear Society Annual Meeting, June 1973.
3. I. I. Pinkel, "Appraisal of Fire Effects from Aircraft Crash at Zion Power Reactor Facility," July 17, 1972 (Docket No. 50-295).
4. D. G. Eisenhut, "Testimony on Zion/Waukegan Airport Interaction" (Docket No. 50-295).
5. USAEC Regulatory Staff, "Safety Evaluation Report," Appendix A, "Probability of an Aircraft Crash at the Shoreham Site" (Docket No. 50-322).
6. "Addendum to the Safety Evaluation by the Division of Reactor Licensing, USAEC, in the Matter of Metropolitan Edison Company (Three Mile Island Nuclear Station Unit 1, Dauphin County, Pennsylvania)," April 26, 1968 (Docket No. 50-289).
7. Letter to Honorable J. R. Schlesinger from S. H. Bush, Chairman, Advisory Committee on Reactor Safeguards, "Report on Rome Point Nuclear Generating Station," November 18, 1971 (Project No. 455).
8. Letter to Mr. Joseph L. Williams, Portland General Electric Company, from R. C. DeYoung (in reference to Mr. Williams' letter of May 7, 1973), November 23, 1973 (Project No. 485).
9. "Aircraft Considerations-Preapplication Site Review by the Directorate of Licensing, USAEC, in the Matter of Portland General Electric Company, Boardman Nuclear Plant, Boardman, Oregon," October 12, 1973 (Project No. 485).
10. Letter to Mr. J. H. Campbell, Consumers Power Company, from Col. James M. Campbell, Dep. Chief, Strategic Division, Directorate of Operations, U.S. Air Force, May 19, 1971 (Docket No. 50-155).
11. H. E. P. Krug, "Testimony on Aircraft Operations in Response to a Question from the Board" (Docket Nos. 50-275 and 50-323).
12. Letter to Mr. J. H. Campbell, Consumers Power Company, from Col. James M. Campbell, Dep. Chief, Strategic Division, Directorate of Operations, U.S. Air Force, May 19, 1971 (Docket No. 50-155).
13. 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities."
14. NUREG-0533, "Aircraft Impact Risk Assessment Data Base for Assessment of Fixed Wing Air Carrier Impact Risk in the Vicinity of Airports."